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Agricultural Research Information System (ARIS)

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The Indian Council of Agricultural Research

in cooperation with

isnar International Service for National Agricultural Research

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1 INTRODUCTION

Agricultural research in India is at the point of major breakthroughs. Indian scientists are among world leaders in fields as diverse as molecular biology, dry land crop production, and agricultural engineering. These men and women produce much high quality work—and there are a lot of them. The Indian national agricultural research system (NARS) consists of more than 25,000 scientists who work at more than 80 major institutes, 27 state agricultural universities, and 1000+ centres and stations.

The major challenge in the 1990's and beyond is to mold such vast resources into a more coherent whole. One of the most effective tools for doing so can be improved information. India is rapidly becoming a world leader in this field also, known particularly for its expertise in computer software development. The marriage is therefore a natural one: agricultural research and information management.

In early 1991, the Government of India (GOI) decided to undertake a major project to bring the power of new information technology to the NARS. This project has been dubbed "ARIS", an Agricultural Research Information System. Most funds are coming from the GOI itself and from the World Bank. The Indian Council of Agricultural Research (ICAR) and the State Agricultural Universities (SAUs) have asked ISNAR[1] to take the lead in formulating a strategy.

The ARIS is based on three assumptions.

i. That the lack of systematic access to information is (and will continue to be) a serious constraint on both management and scientific decision-making in the Indian NARS.[2]
ii. That new technology has the potential for bettering information management.
iii. But that early action is required if information management in the NARS is to be improved.

Too much technology and too many data may actually weaken rather than strengthen decision-making. The challenge is to strike a balance between three inter-related considerations.

a) The need for information.
b) The willingness of NARS managers and scientists to use information.
c) The capacity of these managers and scientists to manage both information and information technology.

1 The International Service for National Agricultural Research. ISNAR is one of 17 centres in the Consultative Group on International Agricultural Research. Its mandate is to work with NARS on issues of agricultural research policy, organization, and management. ISNAR headquarters are in The Hague, The Netherlands.

2 The important word here is "access". A large amount of information already exists in the NARS, but in forms which make use by managers and scientists difficult.

2 GOALS AND OBJECTIVES

The goal of the ARIS is to strengthen information management (IM) within the Indian NARS. There are four specific objectives.

i. To put information close to the managers and scientists who will use it.
ii. To improve the capacity of research organizations to organize, store, and retrieve information relevant to their mandates.
iii. To develop regular procedures and mechanisms for those organizations to share information.
iv. And—as a result of the first three—to improve the capacity of those organizations to plan, monitor, and evaluate their research programs.

The ARIS is primarily concerned with information management, *not* information technology (IT). The following simple tree of means and ends makes this point.

APPROPRIATE INFORMATION TECHNOLOGY
leads to
IMPROVED INFORMATION MANAGEMENT
leads to
STRONGER RESEARCH PLANNING, MONITORING, AND EVALUATION
leads to
BETTER RESEARCH
leads to
MORE BENEFITS TO FARMERS

2.1 The Strategy Development Process

The ICAR and ISNAR divided the strategy development process into two parts: an assessment of needs and an identification of appropriate technologies. The former was carried out in January/February 1993 and the latter in April/May 1993.

2.1.1 TEAMS AND SCHEDULES

The teams for the two parts had some degree of overlap. The first consisted of two persons from ISNAR, one independent consultant, and four senior scientists from the ICAR and the SAUs.[3] All had strong backgrounds either in agricultural research or in information management. The second team consisted of two persons from ISNAR, one consultant, two senior scientists from the ICAR and the SAUs, and two information management specialists—augmented by several part-time resource persons.[4]

[3] Dr. Byron Mook (Director of Information Management Services, ISNAR)
Dr. Ralph Retzlaff (ISNAR Consultant)
Mr. Peter Ballantyne (Director of Library/Documentation Services, ISNAR)
Dr. M. Aravindakshan (Director of Research, Kerala Agricultural University, KAU)
Dr. G.L. Kaul (Assistant Director General, ICAR; now Commissioner of Horticulture, GOI)
Dr. K.V. Raman (former Director General, Natl Academy of Agri Research Mgt, NAARM)
Dr. A.P. Saxena (Assistant Director General, NARP, ICAR)

[4] Dr. Byron Mook (Director of Information Management Services, ISNAR)
Mr. Paul O'Nolan (Director of Computer Services, ISNAR)
Dr. John Grondel (Director, Global Village, Wageningen, The Netherlands)

Each team took approximately 3.5 weeks to complete its job. The table on the following page shows how activities were organized.

In each organization visited, team members talked with a sample of research managers, scientists, and information specialists. Some of these meetings were held in larger groups of 7–10, most were in smaller groups of 3–6, and some were one-on-one. The emphasis throughout was on depth rather than breadth. The objective was to move beyond the formalities of information needs and technologies to understand some of the social, political, and management issues that might affect an ARIS. Over the course of the 7 weeks, the two teams were able to have contact with more than 400 NARS managers and scientists, and more than 150 information specialists.[5]

2.1.2 SUBJECTS

Meetings with ICAR/SAU managers and scientists focused on the following questions:

i. *What types of information do you mostly deal with at present?*
ii. *Where do you get that information? How?*
iii. *What are the current strengths and weaknesses of IM in your organization? Content? Collection? Management? Use?*
iv. *If you could have easier access to better information, how would it help you to do your job better? (Specifics).*
v. *How do you think that an ARIS should develop, and what are likely to be some of the major challenges for the ICAR and the SAUs in getting it established?*

	NEEDS ASSESSMENT	TECHNOLOGY ASSESSMENT
Orientation	0.5 Weeks (New Delhi)	0.5 Weeks (New Delhi)
Visits to ICAR Institutes and SAUs	2.5 Weeks Three Sub-Teams	0.5 Weeks Two Sub-Teams
Visits to Info & Telecom Organizations		1.0 Weeks (New Delhi)
Visits to ICAR Institutes, SAUs, and Info/Telecom Organizations		0.5 Weeks
Visits to Info & Telecom Organizations		0.5 Weeks (New Delhi)
Wrap-Up	0.5 Weeks (Hyderabad)	0.5 Weeks (New Delhi)

Dr. K.V. Raman (former Director General, Natl Academy of Agri Research Mgt, NAARM)
Dr. A.P. Saxena (Assistant Director General, NARP, ICAR)
Dr. B.H. Jajoo (Chairman, Computer Services, Indian Institute of Management)
Dr. K. Gopinath (Asst. Professor, Computer Science/Automation, Indian Institute of Science)

5 At each ICAR institute, the team tried to meet with as many of the following persons as possible: the Director, the head of the Technical Cell, the Senior Administrative Officer, the Librarian, the head of the Computer Unit, All-India Coordinated Research Project coordinators (if any), heads of divisions (at least 2), and practicing scientists (at least 5-10).
Similarly, at each SAU, the team tried to meet: the Vice-Chancellor, the Director of Research, the Dean, the Registrar, the Comptroller, the Librarian, the head of the Computer Unit, AICRP coordinators (if any), heads of departments (at least 2), and regular faculty members (at least 5).

2.1.3 OUTPUTS FROM THE NEEDS ASSESSMENT TEAM

i. *A brief description of existing information resources and IM practices, both inside and between research organizations.*
ii. *An analysis of the strengths and weaknesses of this information and these IM practices.*
iii. *A judgment about the benefits that would occur if information identification and access were to be improved, e.g., through an ARIS.*
iv. *A list of issues that developers of an ARIS will have to face (e.g., data content, data collection and compatibility, organization and management, resources required, etc.).*

2.1.4 OUTPUTS FROM THE TECHNOLOGY ASSESSMENT TEAM

These four products then became the raw material for the technology assessment team. What technology was most appropriate to meet the needs that had been identified? Outputs here included the following:

i. *An analysis of existing Indian telecommunications networks, with particular emphasis on their suitability for the ICAR and the SAUs.*
ii. *An assessment of available (and planned) land line, radio, and satellite technologies as a basis for an ARIS.*
iii. *Details about the computer and communications hardware/software that the ICAR and the SAUs already have and that they will need to procure for an ARIS.*
iv. *Preliminary judgments about the phases (timing, schedule) required for ARIS development.*

The emphasis in the entire process was on the development of a strategy, and *not* on the formulation of a project proposal or a detailed action plan.

3 FIVE THEMES

Five themes will mark ARIS development. Each is noted briefly here and is described in more detail later in the strategy.

3.1 Information Broadly Defined

The ARIS will include information relevant to the performance of three main functions.

i. *System and Institutional* Management. Mainly data on financial, human, and physical resources. The goal is to develop regular procedures for program and project budgeting, monitoring of resource use, and administrative reporting.
ii. Research *Project* Management. Mainly information on the substance of research completed, and usually in the form of books, articles, abstracts, and reports. The goal is to allow scientists to identify needed documents and then to gain access to them quickly. The rationale is that the use of such information will improve research planning, reduce duplication in research efforts, and encourage dissemination of research results.
iii. *Resource* Management. Mainly data on natural resources (e.g., soils, fish catches), germplasm, agro-climatic conditions (e.g., rainfall), and problems affecting agricultural production (e.g., pest infestations). Numerous databases on such subjects now exist in the institutes and SAUs in various stages of computerization. The goal is to enable scientists around the country to use these databases both for research planning and for research itself.

3.2 Users at Different Levels

The development of ARIS networks will occur on four levels. The attention given to each will depend on whether the content is mainly management information, scientific information, or resource data. These four levels are:

i. Between the institute/university and its constituent centers/stations
ii. Within the institute/university campus
iii. Between the institute/university and national organizations
iv. Between the institute/university and the international scientific community.

3.3 A Balance between Autonomy and Order

The ARIS will be as decentralized as possible, in keeping with the objective of bringing information close to its users. Two features of such decentralization will be important.

i. **Flexibility**. The ARIS will not be a monolithic system. Instead, it will consist of separate, loosely linked systems for management information, scientific information, and resource data (cf. the discussion of the three functions on the previous page). Each such "sub-ARIS" will consist of its own procedures and databases, though many of the technologies will be shared. The goal is to let each user choose that part of the overall ARIS that best meets his/her needs.
ii. **Uniformity**. At the same time, some common standards (e.g., software, data formats, and procedures) are necessary because information exchange is one of the main reasons for having an ARIS. Each participating organization and individual must therefore adhere to these standards if the full benefit of the ARIS is to be realized. The goal is to strike a balance: keeping standardization to a minimum, whilst encouraging scientists and managers to

be innovative in developing their own procedures for information management.

3.4 A Long-Term Process

The ARIS will come into being gradually, over a period of at least five and probably closer to ten years. The ICAR will need to set specific targets and to plan activities for each time period. Such planning will be closely related to the issues of content and levels noted in Sections 3.1 and 3.2. For example, the biggest initial efforts on management information will be at levels "i" and "iii" (between the institute/university and its constituent centers/stations, and between the institute/university and national organizations), whilst the biggest push on scientific information and resource data will be at level "ii" (within the institute/university campus).

3.5 People and Technology

The major constraint on the development of the ARIS will be people rather than technology. "Information Management" is a new concept to many agricultural research scientists and managers. Much new "information technology" is intimidating. One of the major goals of ARIS planning, therefore, will be to create an environment in which information is regarded as important, and in which IM skills are seen as part of the tool-kit of each scientist and manager. Training will have two different types of objectives, for three different types of participant. The crosses in the cells of the following table indicate training priorities for the first five years.

	Awareness	**Skills**
Senior Managers, Scientists	**X**	
Information Professionals (Librarians, Computer Specialists)	**X**	**X**
Support Staff		**X**

4 THREE TYPES OF INFORMATION

The ARIS will consist of three types of information: for managers, for scientists, and on natural and physical resources (Section 3.1).

4.1 Information for Managers

The biggest information problem for most senior institute and SAU managers can be summed up in one word: *reporting*.

New Delhi and state capitals continually ask research managers down-the-line for data on budget, expenditure, personnel, and physical resources. Each time such a request comes in, the Director (of the institute), or the Senior Administrative Officer, or the Vice-Chancellor (of the SAU), or the Director of Research, or the Comptroller puts out a special request to his/her subordinates to provide the required data. But since almost no institutes or SAUs have computerized spreadsheets or databases, each request must be dealt with manually and from the beginning.

What will be the objective of including such "management information" in the ARIS? The traditional answer is an increased capacity for planning/programming and monitoring/evaluation. The following table lists the subjects usually covered by a Management Information System (down the left side) and the uses to which this information is usually put (across the top). The words in italics in the cells are the functions that will be addressed by management information in an ARIS.

SUBJECTS FOR INFO / USES FOR INFO	Planning/Programming	Monitoring/Evaluation
Research (Projects)	*Annual Workplans*	*Impact Assessment*
Human Resources (People)	*Recruitment Planning* *Career Planning*	*Performance Appraisal*
Financial Resources (Money)	*Budgeting*	*Accounting* *Auditing*
Physical Resources (Things)	*Procurement Planning*	*Inventory* *Stock Control*

Beyond such a traditional argument in favor of an MIS, however, there is another more non-traditional one. Senior managers told team members repeatedly how much time (and energy) they spend dealing with requests from superiors for information. Team members were left in no doubt that *considerable* management time could be saved if reports and requests could be handled via standard formats.

4.1.1 ACTIONS

The establishment of a basic MIS at each institute and SAU will require the following five actions:

i. Introduction of Standard Computer Software
ii. Agreement on Standard Formats for Information Exchange
iii. Field-Testing at Selected Sites
iv. Training
v. Mandatory Use of the Software and Formats

4.1.1.1 Standard Computer Software

The ICAR must require standard software for MIS work. Such uniformity is necessary if data are to be provided by research stations to the SAUs, by research centers to ICAR institutes, by institutes/SAUs to each other, and—perhaps most important— by institutes/SAUs to the ICAR headquarters in New Delhi. Only four such common software programs are required.

i. A spreadsheet. For financial data. The reporting of many such data from a typical ICAR institute can be done via a relatively simple, off-the-shelf spreadsheet program. Though SAU requirements are more complex, basic reporting from there can also be done with the same piece of software. Such software will complement whatever formal accounting packages the institutes and SAUs already have in place.
ii. A database. For data on research projects, as well as on human and physical resources. Since maintenance of basic data on projects, people, facilities, and equipment is mostly routine, a simple, off-the-shelf program is again sufficient. The one somewhat special requirement for such software is that it should be able to present data in graphics form. Most senior ICAR, institute and SAU managers say that they are able to deal with pie charts and bar graphs much more easily than with large tables of numbers.
iii. A word-processor. For the submission of standard narrative reports. Such software should ideally be able to import data from the two programs above.
iv. A standard utility for data compression.

4.1.1.2 Standard Formats for Information Exchange

The next step is the development of standard formats in the standard software. This task will be an easy one, since most of the required formats are already specified in commonly used, hardcopy "periodical" reports. For example, the format of the monthly expenditure report that each institute submits to the ICAR headquarters in New Delhi has already been determined. All that has to be done is to (re-)create this form in a spreadsheet program.

4.1.1.3 Field Tests

Testing of hardware, software, and formats at selected institutes and SAUs.

4.1.1.4 Training

There will be three target audiences for training in MIS development.

i. Senior institute and SAU managers. The objective of this training will be to increase *awareness* of the potentials of systematic management information.
ii. Computer specialists. Both *awareness* and *skills*. Computer people at the institutes and SAUs have usually not been able to keep up with developments in the PC field. Most use old software, few have manuals even for those programs, almost none have contact with their peers at other institutes and SAUs, and they do not have access to international computer publication(s). Training for this group will have two purposes: first, to familiarize them with the 3-4 standard software packages, and second, to give them practice in the use of the standard file and report formats.
iii. Support staff. *Skills* training, for people who will actually do most of the work.

4.1.1.5 Mandatory Use (Two Issues)

i. Making software available. One of the first jobs for ARIS will be to make the standard software programs available to institutes and SAUs.

ii. Setting deadlines for adoption of both software and formats. Without such deadlines, the establishment of the management information component of the ARIS will not happen. The process of setting such deadlines will occur on two levels: first, at the ICAR level (vis-a-vis the institutes and SAUs), and second, at the institutes and SAUs themselves (vis-a-vis their constituent centers and stations).

4.2 Information for Scientists

The biggest management challenges regarding scientific information can be summarized under two headings: *identification* and *access*. A scientist planning new research must be able to answer (at least) the following two sets of questions.

i. What work on the subject has already been done or is in progress? By whom, where, and when? How have the results of the work been written up: in books, articles, abstracts, and/or reports? Are the project proposals available? (*identification*)
ii. Where are these documents? How can I get copies of them? (*access*)

At the present time, a scientist working at an ICAR institute or an SAU has two sources for trying to answer these questions.

i. The institute or SAU library. Such libraries may once have been adequate, but three developments are making them less so.
   First, agricultural science is growing in size and importance *within India*. The number of national, regional, and commodity-specific journals is increasing. "Gray literature" is becoming more important. The All-India Coordinated Research Projects (AICRPs) and increased travel are making scientists more aware of what colleagues around the country are doing. Scientists may not always be demanding more library service, but librarians feel that such service should be available.
   Second, agricultural science is becoming more *international*, particularly in emerging fields like biotechnology. Institute and SAU librarians would like to be able to use new technologies to access non-Indian information, but few have the skills to do so. Though the demand from scientists is still modest, librarians feel that Indian agricultural libraries are falling behind.
   Third, current financial pressures in both institutes and SAUs have hit libraries hard. Journal subscriptions have been cut (particularly to international journals, which are expensive) and capital purchases have been reduced (e.g., for PCs and library software). Equally important, the funds necessary for new recruitment and for in-career training for library staff are in short supply.

ii. A national document search service. There are at least two such services of primary relevance to agricultural researchers: one organized by the Indian National Scientific Documentation Centre (INSDOC)[6] and the second by the National Centre for Science Information (NCSI).[7] A scientist can use one or both to get current contents, current abstracts, and photocopies of full articles—as well as to contract for on-line searches of international databases.

6 New Delhi. Regional centres in Bangalore, Calcutta, and Madras.

7 Bangalore, at the Indian Institute of Science.

But there are two problems. First, neither INSDOC nor NCSI has advertised its services widely enough, so most scientists (and even libraries) do not know what is actually on offer. Second, services cost money, which most scientists have difficulty organizing (even through their own libraries).

4.2.1 CONSTRAINTS

What will be the biggest priorities for an ARIS regarding scientific information? How strong is the demand for improved services, and where is this demand coming from? Once again—just as in the case of management information—there are both traditional and less traditional answers to such questions.

The usual argument is that scientists *should* have access to all the information they need. An important though untested assumption here is that scientists will use information if it is there. But there is also at least the logical possibility that scientists may not use information even if it is available—if they are unsure about how to use it, and/or if the subjects in which they are interested are defined too narrowly, and/or if their organizations do not reward them sufficiently for using non-traditional information sources. All of these latter conditions exist to some extent at the institutes and SAUs. There are three major constraints on the use of documentary information.

4.2.1.1 Capabilities

Since most scientists have little recent experience with the systematic use of libraries, or of computers, they have minimal understanding of keywords, on-line searches, and file transfers. The ARIS will therefore have to emphasize the following inter-related subjects:

i. Simple and easy-to-use library procedures and technologies for identifying and accessing scientific information.
ii. Training of IM professionals (e.g., librarians) both to use these technologies themselves, to encourage their staffs to do so, and to set up service-oriented procedures to assist scientists.

4.2.1.2 Interests

Team members routinely asked scientists about the ways in which they actually used information. Many of their answers indicate cautions for an ARIS.

i. How often do you use the library at your institute or SAU? Most scientists said “not often”. Their reasons ranged from inconvenient locations, to too few journals, to too many students (at the SAUs), to unhelpful library staff.
ii. When you do use the library, which are most important: national or international journals? Here the answers were mixed. Some scientists said “international”, but admitted that they seldom looked at more than the same 1-2 journals. A few others said “international”, but said that they looked only at abstracts. And a surprisingly high number—a clear majority—said “national”, on the arguments that most of their work was region-specific and/or mainly adaptive.

4.2.1.3 Rewards

Most scientists did not see clear connections between well-documented research proposals, approval of those proposals, and rewards for research well carried out. Without such connections, incentives to identify and to access new information sources will obviously be low.

4.2.2 ACTIONS

For the purposes of an ARIS strategy, the "identification" and "access" functions described above can be described in terms of five essential tasks.

i. Procurement and storage—of books, journals, abstracts, reports, papers, and various types of "gray literature".
ii. Indexing and cataloging of these acquisitions—including creation of electronic catalogs available for users both inside and outside the organization.
iii. Dissemination of current awareness bulletins, tables of contents, etc.
iv. Delivery of documents—to users both within the organization where #'s i-ii occur, but also to users outside.
v. Synthesis and review of documents on single subjects. Bibliographies, reviews articles, etc.

No single organization in a network like the ARIS can perform all five tasks for the entire NARS. *Instead, different types of organization will have to take on different parts of the job.* The table on the following page presents a possible division of labor. Organization and management issues with regard to scientific information will be much more complicated than those regarding MISs. The amount of data is much bigger, the number of "information managers" required is much larger, and the number of potential users is much greater. Five categories of action will be required within the first 2-3 years.

4.2.2.1 Standard Library and Bibliographic Software

The ICAR will strongly recommend that standard software be used for scientific information work. The computer environment with regard to scientific information is perhaps somewhat easier than for management information, since only the two following basic programs will be required:

i. A program specifically designed for library and bibliographic activities. For cataloging, and as a basis for future electronic catalog searching.[8]
ii. A word processor. For the development of current awareness bulletins, lists of current contents, bibliographies, etc.

8 There are several Indian possibilities. The team(s) were informed that INSDOC has developed a system using dBase, that IIT (Kanpur) has written a program, and that other research and/or educational organizations are working on similar projects. An international option worth considering is CDS/ISIS (from UNESCO). This program is widely used throughout the world, is available free-of-charge, and a large number of librarians at ICAR institutes and SAUs have already been trained in it. An alternative may be PC-MINISIS (from IDRC, Canada). This program is a follow-up to the MINISIS version which many NARS have been using on Hewlett-Packard 3000 minicomputers. The new PC version is due for release sometime in 1994.

	Procurement and Storage	Indexing and Cataloging	Current Awareness	Circulation and Delivery	Synthesis and Review
National Agricultural Information Centres[9]	Large collections	National databases	High priority	Internal	Minimal
Specialized Information Centres—by Discipline or Crop[10]	Small collections	Specialized databases	Priority	Internal and external	Internal and external audiences
Specialized Information Centres—by State and/or Region[11]	Medium-size collections	Specialized databases	Priority	Mostly internal	Mostly internal audiences
Specialized Information Centres—by Function[12]	Small collections	Database management	Minimal	Minimal	Minimal

4.2.2.2 Computerization of Library Catalogs

This action is the *highest* priority, after standard software has been agreed on. No electronic document identification by users *outside* a particular organization is possible until its library catalog has been computerized. This catalog must include both formal publications and "gray literature".

4.2.2.3 Commitment to Use of AGRIS[13] Formats

The philosophy here is to build on what already exists. AGRIS is *the* most well-known agricultural information system in the world. Its coverage of agricultural research, development, commodities, and disciplines is worldwide. Almost all countries contribute at least some materials to it. For India, the Agricultural Research Information Centre (ARIC) in New Delhi has responsibility for coordinating and managing submissions from the ICAR institutes and SAUs.

AGRIS should be one of the most valuable information resources for Indian scientists. It is of limited utility at present, however, because only a small percentage of Indian journals is covered.[14] If an Indian scientist wants to find citations about Indian research, AGRIS is not likely to be of much help.

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9 For example, the Indian Agricultural Research Institute (IARI, New Delhi), the Indian Veterinary Research Institute (IVRI, Izatnagar), the National Dairy Research Institute (NDRI, Karnal), and the Central Institute of Fisheries Education (CIFE, Bombay).

10 Mainly ICAR institutes. In some cases, Project Directorates and All-India Coordinated Research Projects.

11 Mainly State Agricultural Universities (SAUs).

12 Organizations charged with specific responsibilities within the ARIS. Possible examples include the Agricultural Research Information Centre (ARIC, New Delhi) and the National Academy of Agricultural Research Management (NAARM, Hyderabad).

13 The International Information System for Agricultural Sciences and Technology, organized and managed by the Food and Agriculture Organization of the United Nations.

14 An estimate of what this percentage is depends, in turn, on an estimate of the size of the potential information resources (journal articles, "gray literature", etc.). Most estimates given to the team(s) were that only 5%-10% of relevant Indian information finally gets into AGRIS, and that 90%-95% does not.

The way forward will be to decentralize a significant number of Indian AGRIS operations. The jobs to be done are simply too big for one small unit to handle. Precise responsibilities and divisions-of-labour between ARIC and the NSICs can be worked out. No *formal* change in arrangements with FAO will be necessary, since ARIC can continue to be the designated AGRIS center for India.

The goal will be to have all Indian agricultural journals and "gray literature" included in AGRIS. The ICAR institutes and SAUs will then be able to use the Indian subset of the overall AGRIS database as an Indian *national* database.[15] A policy decision in this direction is logical, given the top priority that scientists place on access to *national* information and the experience that many IM professionals in the NARS have with AGRIS.[16]

4.2.2.4 Liaison with Existing Networks

The objective of such liaison is to benefit from the head-starts made by INSDOC and the National Information System for Science and Technology (NISSAT). The ARIS will tie into some of the NISSAT networks—and even where it does not, it can learn lessons from them about hardware, software, management, and resources required.

The inter-library network in New Delhi (DELNET) is a promising example of beginning small. At the present time, DELNET consists of simple email connections, supported by commitments from the various libraries to supply material via inter-library loan. If one library in the network wants a book, journal, or paper—for example—it sends an email request to some or all of the other libraries on the network. If one of them has the material, it sends it in hardcopy. The long-term objectives are that both such document identification and delivery will be done electronically.[17]

4.2.2.5 Training and Continuing Support

See Section 4.1.1.4 on the training required for a basic MIS. The training needed regarding "scientific information" is not dissimilar. There will be two target audiences here.

i. Librarians. Mainly *skills* training. For the first 2-3 years of the ARIS at least, library professionals will be the ones doing most document identification and delivery. Scientists will be brought into such training later on, once the procedures for CD-ROM and on-line searches and retrievals have been established.
ii. Library support staff. *Skills* training, for the people who will actually do most of the work.

4.3 Information on Natural and Physical Resources

Institutes, SAUs, centers, stations, and AICRPs have traditionally generated massive amounts of data in the course of doing their research. Scientists have written down experimental designs in project proposals, collected data in field or lab, and recorded these data in

15 This national subset can then be issued on CD-ROM at annual or bi-annual intervals, perhaps broken down by commodity and/or region.

16 The fact that there are standard AGRIS formats is not a constraint. India will be able to make its submissions to the main international database in standard formats, but will be able to add national fields and local variations for use by Indian scientists.

17 NISSAT is part of the Department of Scientific and Industrial Research, New Delhi. The July-September 1992 issue of the NISSAT Newsletter noted that an inter-library network in New Delhi was already in operation (DELNET) and that a similar one was beginning in Calcutta. (CALIBNET). Plans for Bombay (BONET), Pune (PUNENET), Madras (MALIBNET), Hyderabad (HYLIBNET), and Ahmedabad (ADNET) were being worked out then, and some are now in operation.

notebooks and files. Some institutes and SAUs literally have rooms full of such historical data. They tend to fall into five general categories.

i. On Resources. Examples include data on germplasm ("genetic resources"), soil characteristics ("production resources"), and fish catches ("natural resources").
ii. On Agro-Climatic Conditions. Mostly data on temperature and rainfall, used for analyses of production and weather forecasting.
iii. On Pests and Diseases. Data on attacks—usually by time period, by location, and/or by crop or animal affected.
iv. On Socio-Economic Conditions. Data considered relevant to explanations of why farmers adopt (or do not adopt) recommended cultural practices.
v. On Research Results. Experimental designs, results, and analyses.

The advent of personal computers has opened up new possibilities for managing and using these types of data. But the important question for any NARS is how many such data it should try to aggregate, computerize, and make available for analysis beyond the organizations (and individuals) that collected them. *Priorities have to be set.* At most institutes and SAUs, for example, some types of resource data go back 80-100 years and some have been collected at a level of detail that are likely to make the cost of computerization higher than the potential benefit.[18]

The biggest challenges to an ARIS regarding resource management data again concern *identification* and *access*. Most scientists do not know what data on resources exist, where they are, what they include, and who is responsible for managing and granting access to them.

The ARIS approach toward the management of resource data is based on four assumptions. The starting point is a realization that only a small portion of these data can and should be made widely available.

i. That the costs of computerizing most historical data probably outweigh the benefits.
ii. That basic agro-climatic and socio-economic data are already available from Central and State governments, and that both quality and access to them will improve. Categories "ii" and "iv" above.
iii. That most pest/disease and experimental data will and should remain mainly with the organization(s) and scientist(s) who collected them. Categories "iii" and "v" above.
iv. That, therefore, the highest priorities for national databases are in the fields of genetic, production, and natural resources. Category "i" above.

4.3.1 ACTIONS AND PHASES

The process of incorporating resource management data into an ARIS will occur in four distinct phases.

4.3.1.1 Training

The emphasis here will be more on *awareness* training for managers and scientists than on the acquisition of particular *skills*. The focus of such training will be on three subjects.

18 Several SAUs, for example, have rainfall and temperature data going back to the early years of this century. These data have usually been averaged (at least) monthly for (at least) each district. Similarly, one SAU has a massive amount of data on pest infestations—collected in (sample) villages, weekly, for each crop, over most of the past decade. All the data are in hard copy and the file folders fill most of a room.

i. Familiarization with the content of existing national databases (particularly those dealing with genetic resources, agro-climatic data, and socio-economic data).[19]
ii. Exposure to means by which scientists at institutes and SAUs can access these data.
iii. The use of simple PC-based software for creating and maintaining databases at the institute and SAU level on genetic, production, and natural resources, as well as on research results.

4.3.1.2 PCs for Management of Resources Data

The goal is to have scientists put their data in formats that both they and others can use. Two actions are envisaged.

i. Backup support to managers and scientists who have received the *awareness* training described above.
ii. Incentives to those managers and scientists who make active commitments to use PCs for database management. These incentives may take the form of preferred access to hardware, to support services, and to training opportunities.

4.3.1.3 Development of File Transfer Capabilities

The issue here is primarily technical. The ARIS network technology will support the transfer of database files between institutes and SAUs. The goal is to allow scientists working on similar subjects to be able to exchange not only notes but also actual data.[20]

4.3.1.4 A National "Database of Databases"

A central repository of information on what resource management databases exist, where they are, what they contain, what formats they use, and who manages them. The idea is that a scientist who uses this "database of databases" can *identify* which particular databases (s)he wants to use, make contact with the scientists who manage them, and finally *access* the material in them.[21]

19 A good example is NICNET, the National Informatics Centre Network. NICNET carries many databases on a wide variety of subjects, including ones that contain basic district-level socio-economic information. Any scientist can access NICNET through a district headquarters office.

20 One of the prime beneficiaries of this capability is expected to be the All-India Coordinated Research Projects.

21 As in the case "scientific information", ARIS can benefit from some of the work already being done by NISSAT.

5 NETWORK DEVELOPMENT (LEVELS)

The ARIS will develop on four levels. The emphasis at each will depend on the type(s) of information that are most important for users there. The four levels are described here in descending order of priority for ARIS development. Highest priority first.

a.	Between	Institute/SAU and Center/Station
b.	Between	Institute/SAU and National Organization
c.	Within	Institute/SAU
d.	Between	Institute/SAU and the International Community

5.1 Between Institute/SAU and Center/Station

For most institute and SAU managers, the *highest* communications priority is to improve links with centres/stations. Their reasons are both administrative and political. When a request for information arrives from higher authorities, the manager usually passes it on to centres/stations. But then delays almost always occur—either because the original request is unclear, and/or because the centre/station does not have the data, and/or because the centre/station submits incorrect or partial data. Whatever the problem, managers feel that it could almost always be solved quickly if they could pick up a telephone or—better—send an email.

In the short-term, a computer-based communications network linking institutes/SAUs with centres/stations will be primarily used for messages and file transfers. An institute Director, an SAU Vice-Chancellor, or an SAU Director of Research will be able to request information directly (and instantly) from a centre/station. Requests for clarification and corrections can be handled on an almost interactive basis. The adoption of standard computer software for research program management, personnel management, and financial management will mean that most data requested will be available in formats that can be easily manipulated and sent via email.

In the medium-term, the use of this network will expand from managers to scientists. Researchers at centres/stations can be expected to use it initially to request scientific information from the library at the institute/SAU. But in the longer term—as more scientists get more access to email facilities—people doing research on similar subjects will be able to communicate with each other directly, to exchange both actual data and analyses.

5.2 Between Institute/SAU and National Organizations

For most institute and SAU managers, this level is a *second* communications priority. The logic and future possibilities are nearly identical to those noted immediately above for the first level. But one exception—the one that makes development at this level of somewhat less importance—is the current availability of telephone and telex links. Since most institutes and SAUs are in or near larger cities, connections already exist with the headquarters of national organizations (e.g., in New Delhi). For them, the main advantage of an ARIS is that it will be more reliable and will be able to carry larger amounts of data.

5.3 Within Institute/SAU

For both managers and scientists, the improvement of communications links within the campus is a third priority. The reasons for this lower ranking are clear. As managers at most institutes and SAUs have no experience with email, the question as to whether they would like to have an intra-campus “Local Area Network” (LAN) is largely academic. Their assumption is that most intra-organizational communications can and will continue to be

handled in other ways. Telephones now carry some intra-campus message traffic, supplemented by hardcopy data that are hand-carried around the campus as required.

Once a LAN is established, however, the user community can be expected to grow quickly, enthusiastically, and sometimes even in unexpected directions. Almost all academic and research organizations that have introduced intra-campus email have found that it has fundamentally changed the ways in which they operate. Managers communicate with scientists more, as do scientists with each other. Requests for action, calls to meetings, and information about institute/SAU happenings become routine.[22]

5.4 Between Institute/SAU and the International Community

This fourth level is the lowest priority at present, but will rise significantly as soon as the ARIS is established. Since most managers and scientists do not communicate regularly with peers outside India, they have trouble estimating how much they would use such facilities were they available. The experience of most organizations, however, both in India and outside, is that once international email and file transfer capability exists, it is heavily used.[23]

22 Managers set the tone. Senior managers in most countries have never used a typewriter before, much less a PC. Therefore, not only are they reluctant to spend time on basic training, but there are also issues of status. Numerous management studies have made the following three points. (1) The time required for a manager to learn basic email is very short (one-two hours). (2) A manager who uses email finds that his/her status suddenly rises. Subordinates respect and admire a boss whom they see as being on the cutting edge of communications technology. (3) Email also tends to increase the power and authority of senior managers. Orders can go out to subordinates more quickly and replies can be expected on time. Communication between superiors and subordinates increases and is more task-oriented.
A site in which email could make a significant management difference is Krishi Bhawan itself.

23 There are two kinds of information: that which we know, and that which we know how to find. Email can be very useful in finding information. For example, a scientist can send the same email message or question to several colleagues at the same time (a “distribution list”). (S)he may have one such list for each ongoing research project, one for each AICRP of which (s)he is a member, etc. Selection of one of these lists for an email message is as easy as selecting a single name.

6 NETWORK DEVELOPMENT (TASKS)

A fully developed ARIS will improve the ways in which managers and scientists can perform three functions. The first two are performed at present—usually not electronically, and often with considerable difficulty—while the third will be new. They are arranged here in the order in which they will become operational as the ARIS develops.

a) Message Exchange and File Transfer
b) Document Identification and Access
c) Remote Computing

6.1 Message Exchange and File Transfer

The primary vehicle for message exchange in the ARIS will initially be email. The proposed ARIS email system will have four distinct advantages over existing technology (e.g., telephone, fax, and telex).

i. Reliability. Since much of the network will operate independently of terrestrial lines, it will not be subject to many of the inconveniences now affecting telephone, fax, and telex users. A manager or scientist will be able to sit at a keyboard, type a message, hit a key, and be reasonably certain that the message will arrive at its destination (as soon as the recipient logs in to collect it).
ii. Coverage. The sender of a message will be able to address more than one person simultaneously. If—for example—the national coordinator of an AICRP wishes to inform all members of plans for an annual meeting, (s)he will be able to compose just one message, and the message will go to all members on the AICRP distribution list. When researchers around the country receive it, they will be able to reply immediately if they wish.
iii. Cost. Email will be much cheaper than telephone, fax, or telex.
iv. Speed. Email messages will move more quickly than those sent by fax or telex.

These same four advantages apply to “file transfer”. A manager who requests information from a subordinate usually wants an answer back as soon as possible. At the present time, the request goes out by telephone, fax, telex, or post. The subordinate gets the relevant information together, has it typed, and then (usually) posts it. This “turn-around” time will be dramatically reduced with an ARIS, for two reasons.

i. Common Software. Each institute/SAU will be required to adopt the small number of common software packages (Section 4.1.1.1). When used for basic program, personnel, and financial management, these packages will provide means by which organizations can maintain and exchange data and analyses in standard formats. An SAU Director of Research can expect—for example—that managers at all his stations will be using the same spreadsheet, database, and word processing programs.
ii. Ability to Attach Files to Messages. A simple example will make the potential of this capability clear... An institute Director may ask the head of one of his centres for a summary of funds spent on staff travel, broken down by research project if possible. With the ARIS, the centre head will be able to send a brief email reply—and then to attach to that reply (electronically) a file containing all the necessary information. IF the institute and the centre

are using common software, the institute Director will be able to read this incoming data file immediately.

6.2 Document Identification and Access

There are several traditional means of document *identification* (Section 4.2). Perhaps the most common is to look at the card catalog in a library (for books). Another is to go through one or more of the "abstracting journals" that are now subscribed to by many libraries (for articles). A third is to look for citations in journals to which one's own library already subscribes (for both books and articles). And a fourth is to depend on personal contacts within one's organization or at professional meetings (mostly for "gray literature").

Many scientists say that identification is the easy part. Once one has found a reference to an article that one thinks might be interesting, the more difficult problem is to get *access* to a copy. The ARIS will address both these challenges.

6.2.1 CURRENT AWARENESS SERVICE

Identification (1). Under this heading, the first priority for an ARIS will be to expand existing document identification capabilities. One model here is the CAPS[24] service now being run by INSDOC. At least in the short-term, the ARIS will depend on INSDOC for the performance of many "current awareness" functions. Subscription charges to CAPS are not high, and current coverage of agricultural journals can be increased. Institutes, SAUs, centres, stations, and individual scientists will be encouraged to subscribe.[25]

In the medium-term, however, the ARIS will seek to develop some of its own CA capabilities at two levels in the NARS.

i. **Commodity**. Under the ARIS, a small number of commodity-based institutes will run CAPS equivalents covering their particular commodities in more detail. Obvious candidates to perform this function include the "National Agricultural Information Centres" (Section 4.2.2).[26] In return for increased financial support from the ICAR, libraries at these institutes will be authorized to build up their holdings and to provide additional services (including CAPS) to other institutes and SAUs. The long-term objective is that each of these institutes will provide an integrated information service in its mandate area.[27]

ii. **Institute/SAU**. This level is the most immediate one for individual scientists. Under the ARIS, the library at each institute/SAU will perform two "current awareness" functions.

First, it will act as an intermediary between scientists and CAPS services at the national and commodity levels (above). And second, it will undertake expanded CA programs within the institutes/SAUs themselves. Training will be important. Librarians will have to be trained to

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24 Contents, Abstracts and Photocopies Service. The INSDOC brochure for this program says: "Under this service, on an yearly subscription, *you can get the contents of 40 journals selected by you from about 5000 core Indian and foreign periodicals* pertaining to different disciplines. On browsing the contents, you can order the abstracts and/or photocopies of full articles of your choice..."

25 For smaller organizations, contents of 40 journals may be enough. For larger ones, contents of 80 or 120 may be needed. INSDOC currently charges Rs.1500 for an annual subscription to one "set" of 40 delivered by email (or Rs.1200 for one set delivered by post).

26 IARI, IVRI, NDRI, and CIFE.

27 Such a service on "crops" may well be too big a job for one institute alone. ICAR may therefore decide to break the "crops" field down into 3-4 smaller sub-fields.

become better aware of what CA services are available, how scientists can get access to them, and how to integrate CA services at the institute/SAU, commodity, and national levels.

6.2.2 BIBLIOGRAPHIC SEARCHES

Identification (2). CA services such as CAPS are useful for scientists who know (in advance) which journals are most likely to contain articles of interest. But for scientists who would like to go through a much larger number of journals, other means are necessary. There are two prerequisites for using keywords in such searches: first, that all article titles (and accompanying abstracts, if possible) be computerized, and second, that librarians be trained in identifying keywords and in conducting searches.

The ARIS will develop capacity for searches on the two levels noted above.

i. **Commodity**. The first step will be for libraries at the four commodity-based institutes (above) to plan their future journal holdings. Which journals should they subscribe to? The second step will be to begin an intensive program of computerizing titles and abstracts—not only of journals, but also of reports and of "gray literature". And finally, as the third step, these libraries will begin to offer specialized bibliographic search services to scientists at institutes/SAUs.

   Two technologies will be important in the provision of such services. First, personal computers running appropriate documentation-management software. And second, CD-ROMs with subscriptions to appropriate international databases.

ii. **Institute/SAU**. A similar process will be undertaken at institute/SAU libraries, but with two important differences. First, the initial emphasis at this level will be less on journals and more on reports and "gray literature" (which, in the case of SAUs, are likely to be primarily of state interest). Second, there will be much less attention to CD-ROMs.[28]

6.2.3 PHOTOCOPYING AND FULL-TEXT RETRIEVAL

Access. After a scientist has located a citation—perhaps through a current awareness service, or perhaps through a bibliographic search—the next challenge is to get access to a copy. The CAPS from INSDOC now provides such a service.

At the same time, selected institutes will be encouraged to develop their own document delivery services. Since this capability is so closely linked to current awareness and bibliographic search services, the initial focus will be on the four commodity-based institutes noted above. Library staff at other institutes and SAUs will be trained to take a more active role in assisting scientists to order documents from these four institutes. Libraries will receive resources specifically designated for this purpose.

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28 This point requires some explanation, particularly since CD-ROM technology is now widely used in libraries in North America and Western Europe. ARIS will not encourage immediate acquisition of CD-ROMs at the institute/SAU level, for three reasons. (a) Cost. Even though CD-ROM hardware is relatively cheap, annual subscriptions to international databases are still *very* expensive. (b) Coverage. Most CD-ROM databases are still quite "northern" in orientation, and material from very few Indian journals is included. (c) Management. Time demands on library staff will rise dramatically if scientists depend on them for frequent CD-ROM searches.

All three of these considerations are likely to change in the next 3-5 years. More and more material will be included in Indian databases. At least some of these databases will be made available on Indian-produced CD-ROMs. Library automation will increase. And both library staff and scientists will become increasingly familiar with the use of PC and CD-ROM technology. INSDOC has recently made a policy decision that CD-ROM drives will be included in all new PCs that it purchases.

In the longer-term, the ARIS will attempt to develop a capacity for full-text retrieval. With FTR, a scientist will be able to sit at a computer, search a database at a distant library, identify an article, and "download" a copy of the article to his/her screen. Achievement of this goal is still something for the longer-term, but it is not as technically difficult as might be assumed. There are two major prerequisites. First, a working telecommunications network that can handle large files at high speeds. And second—both more important and more difficult—the computerization of library catalogs so that they can be searched electronically. Over the next 5-10 years, the ARIS will deal with fulfilling both conditions.[29]

6.3 Remote Computing

Like "full-text retrieval", performance of this third function is also an activity for the longer-term. A good example is the massive amount of data on natural and physical resources that institutes, SAUs, centres, and stations have traditionally generated (Section **4.3**). As they begin to computerize such data, an objective for the ARIS will be to allow scientists at other places to get access to them and to perform analytical operations on them "on-line". At present, a scientist in Bangalore can "log on" to a computer in California but cannot do so within the ICAR network.

Once again, there are two prerequisites (roughly the same two as noted for FTR). First, telecommunications capability, and second, computerization of the data themselves. Once such conditions have been met, a scientist in one part of the country will be able to discover data at other places, look at whichever of those data are computerized, and use them for his/her own analyses.

29 An additional issue that will affect the development of FTR is copyright law. Journal owners are understandably reluctant to allow *free* access to journal contents. Considerable thought and negotiation is going on in North America and Western Europe on this issue, with the probability that some kind of nominal pay-for-access system will be developed.

7 NETWORK OPTIONS

The Indian market for computers, telephones, and improved telecommunications is booming. The Centre for the Development of Telematics (C-DOT) estimates that a new telephone exchange is being commissioned somewhere in the country every day. STAR-TV has said that India is its fastest growing Asian market in terms of both audience and advertising. Most major government offices now have fax machines, and the private sector in particular is beginning to use email. Both public and private organizations are supporting the development of telecommunications networks.

In such an environment, the logical choice for the ICAR is to use an *existing* network for the ARIS rather than to try to build its own independent system. Not only will such a choice save money, but the ICAR will be able to benefit from the management expertise and technological experience that other organizations possess.

There are several potential partners. One of the major tasks of the second ARIS strategy team was to assess potentials for collaboration between these networks and the ICAR. Its conclusion was that there is no single service provider able to meet all ICAR needs, though one stands out as providing the most solid growth potential for the next fifteen years.

7.1 Potential Network Players

There are obviously many organizations that the ICAR may wish to involve in the development of a large project like the ARIS. The following list is not exhaustive, but is rather intended to identify organizations that are likely to have some part in the process.

i. NICNET (National Informatics Centre Network)
ii. ERNET (Education and Research Network)
iii. NCMRWF (National Centre for Medium-Range Weather Forecasting)[30]
iv. INSDOC (National Scientific Documentation Centre)

7.1.1 NICNET (THE NATIONAL INFORMATICS CENTRE NETWORK)

NICNET was commissioned in 1977. It has centres at the regional level (e.g., Delhi, Pune, Bubaneshwar, and Hyderabad), in all the state capitals, and at the district level. Offices on the network communicate mainly by satellite. NICNET provides access to several well-known on-line databases on subjects as varied as medicine (e.g., MEDLINE), agriculture, revenue administration, and urban planning. Any approved user may gain access to these resources through the NICNET installation at the nearest district headquarters.

NICNET is the most well-known electronics-based network in India. Part of its reputation stems from its organizational position as a unit of the Planning Commission. Part comes from its (deserved) image as a pioneer in satellite-based communications. Part comes from its geographic reach, into every district. Finally, part comes from the fact that it is still almost the only network player *within* government. If a public sector organization or office wants networking facilities, the first place to which it will look is likely to be NICNET.

This pre-eminent position has been further strengthened by political fiat. In some states, Government has ordered that officials use NICNET in preference to telephone or telex. At the central government level, similar directives exist.

30 Part of the Department of Science and Technology (DST).

The fact that NICNET is still not used nearly as widely as NIC would like it to be results from several management and technical considerations. Four are most important.

i. **Structure**. NICNET is a Government of India undertaking. It has therefore been able to establish itself in a protected environment, without having had to pay too much attention to market demands. Its management structure and R&D activities are quite centralized. Most NICNET managers and technical staff are based in New Delhi, and most R&D work and planning occur there.

ii. **Email**. NICNET is primarily India-oriented. Connections to international users over the Internet are possible but difficult,[31] and the sender must pay for each connection. Internet Protocol (IP) connectivity[32] and true "store-and-forward" capabilities are still being developed. File transfers are limited by size.

iii. **Technology**. The basic NICNET philosophy is one of "point-to-point" communication. If A wishes to contact B, (s)he first connects with the network hub in New Delhi and leaves the message or file. All mailboxes are on one of several mainframes there. B then also connects with New Delhi and picks up the data. Messages are restricted in size because of disk storage limitations. As late as 1993, communications over NICNET moved at a maximum speed of 1200 bps for district-level communications and 9600 bps at other selected sites.

iv. Recently, however, NIC has taken the lead in development of a national "Information Highway". This new network connects approximately 70 cities with a speed of 1MBPS, extended to 2MBPS at selected nodes. The precise relationship of the new Information Highway to the original NICNET is being elaborated.

v. **Service/Support**. The NICNET offices in the district towns are often staffed by junior personnel, who understandably find it difficult to keep up-to-date with the fast-developing technologies that they are called upon to administer. Most therefore tend to be reactive rather than proactive in encouraging local users, even though they are critical links in the user chain. A scientist at a research institute or SAU who wishes to use NICNET must place a telephone call to the district access point for forwarding via satellite. Problems can and do occur with either of these two links in the pre-satellite chain, namely, the phone call to the access point and/or the forwarding.

7.1.2 ERNET (THE EDUCATION AND RESEARCH NETWORK)

ERNET is part-government and part-private. It was started with support from UNDP and the Department of Electronics (DOE), but now gets most of its revenue from subscriptions. Small institutions pay 1 lakh per year and large ones pay 2 lakhs.[33] The target clientele is R&D institutions, for whom one of the biggest attractions is access to the Internet.[34]

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31 The NICNET email system is based on the X.400 protocol. This standard is, however, rapidly being overtaken by Internet-standard addressing (i.e., SMTP, the Simple Mail Transfer Protocol). International connectivity for NICNET is through the GPSS Gateway of VSNL in Bombay and via a 64KBPS link to SPRINTNET in New York.

32 NICNET is not IP-based, and is not therefore technically part of the Internet.

33 There are possibilities for multi-site organizations (e.g., ICAR and/or SAUs) to take out group subscriptions, in which case the annual cost per site can be as low as Rs.25,000.

34 The Internet is really "a network of networks". It was created to allow users on one network (e.g., ERNET) to have access to data on other networks (e.g., academic/research networks in North America and Western Europe). The growth of the Internet—which has provoked much of the current talk about "information superhighways"—is dependent on two related phenomena. First, the growth of telecommunications technology, and second, adherence by participating networks to a minimum set of software standards.

ERNET is built around eight "nodes", most of which are at the Indian Institutes of Technology (IITs). These nodes are connected via either leased or dial-up telephone lines. Access outside India has historically been via a 64k bps gateway at the National Centre for Software Technology (NCST) in Bombay, though a new satellite link in the Software Technology Park (STP) in Bangalore will soon become operational. For a new subscriber, the ability to dial-up to one of the eight nodes is critical.

Growth of the network has been rapid, but perhaps not quite as rapid as its founders would have liked. One of the major problems has been money,[35] though there have been others as well. ICAR institutes and SAUs will need to take six considerations into account in evaluating a possible future relationship with ERNET.

i. **Structure**. ERNET is quite decentralized. Its administrative headquarters are at the DOE in New Delhi, though R&D work occurs at nodes throughout the country. Because it does not exist in a protected environment, it has to sell its services and to adapt itself to user needs if it wants to survive.

ii. **Philosophy**. ERNET was originally set up to do R&D on networking, not to provide service. Some observers feel that even today it is run and used mainly by a small part of the Indian academic community (though it claims to be one of the biggest Indian networks in terms of number of users and traffic volume).

iii. **Ease of Access**. A manager or scientist who wants to use ERNET must dial-up to the nearest of the eight ERNET nodes. This dialing will usually involve a trunk call. Once connected, however, the user will be able to use standard, internationally recognized software and procedures to access remote networks, and to send and receive messages and files.

iv. **Email**. ERNET was conceived as the first significant extension of the Internet in India. Its email capacities are therefore the standard ones for international communications. When a user connects to the network, (s)he can send and receive to and from any point. Communication is therefore "distributed" rather than "point-to-point". Messages sent are "stored" and "forwarded". File transfers are routine and are not limited in terms of size.

v. **Technology**. Most traffic over ERNET moves now at 9600 bps, though moves to higher speeds are being planned. Full IP connectivity is standard.

vi. **Service/Support**. Documentation about ERNET operations is scarce. Training for new users is largely *ad hoc*, though NCST does offer courses for existing and potential subscribers. If a user has a problem, there is no clear point or person to contact. Senior ERNET officials talk about setting up a separate "ERNET Society" that would have service as its major mandate.

7.1.3 NICNET AND ERNET COMPARED

The following table summarizes the differences between these two major networks. On balance, ERNET appears to be the more suitable choice for the ARIS.

One example will make this point... In 1991, information specialists at the University of Minnesota developed a tool to allow UM faculty and students to find information that was scattered around the campus network. Because this information had always been difficult to find, and had to be "dug" for, they called their new tool a "gopher". (A gopher is a small, North American rodent, which lives underground and therefore has to dig a lot). In the space of less than three years, this "gopher" has become an international software standard, installed on computers around the world as a means of locating information on the Internet (of which the original UM campus network is now only one tiny component). *Standards* again... The Internet will continue to evolve and is unlikely to be replaced by anything new. Any network, anywhere (e.g., NICNET, ERNET, etc.) which wants to be part of it must adhere to its standards.

35 For example, ERNET has had 20 VSATs stored in a basement at DOE in New Delhi for almost two years. It has not been able to install them because of lack of funds, though there are plans to do so in 1994-95.

	NICNET	ERNET
Technology[36]	**Centralized**	**Decentralized**
Main User Group	Government Ministries	Academia/Research
Policy	Supply-Driven	Demand-Driven
Internet Connectivity (IP)	Under Development	Yes
International Email	Through NIC HQ	Yes
Distributed Store-and-Forward Email	Under Development	Yes
File Transfer	Low Volumes Only	Yes
Access to National Databases	Yes	No
Speed	1200 bps (Most Sites)	9600+ bps
Service/Support	Formal	Informal
Training	Some	Little
Geographic Coverage	Extensive	Limited
End-User Cost	Nominal	Subscription

7.1.4 NCMRWF

NCMRWF is in the early stages of setting up its own national network. It has four reasons for doing so.

i. Need for exclusive use of a network when a weather crisis is looming.
ii. Need to send high-resolution graphics (e.g., maps), particularly during periods of crisis.
iii. Need to communicate directly with organizations that are close to farmers.
iv. Need to be able to send and receive internationally.

The centrepiece of NCMRWF operations is a Cray supercomputer in New Delhi. The network envisioned will be mainly satellite-based. It will use Indian-produced VSATs,[37] located, inititially, at the SAUs and, later, at the Zonal Research Stations.

NCMRWF is interested in cooperating with the ICAR and the SAUs on network development. Several questions will have to be answered, however, before such cooperation can become a reality.

i. **Management**. Who will be in charge of such a joint venture? Neither NCMRWF nor ICAR/SAUs have the necessary capabilities now. If responsibility for day-to-day operations is to be given to another government agency or network, which will be the main candidates?
ii. **Technology**. Is a satellite-based network the most appropriate choice for agricultural research? NCMRWF thinks that it is, mainly because of "last mile" problems.[38] If so, what satellite, what band, and what ground station?[39]

36 Based on internationally standard software, primarily network protocols and utilities.

37 Very Small Aperture Terminals, i.e., satellite dishes.

38 The "last mile" problem is one that both NICNET and ERNET face. For NICNET, communications between the district and New Delhi usually move well (via satellite), but if a user one mile down the road from district headquarters cannot get a good telephone connection, (s)he cannot log on. Similarly for ERNET, communications between the eight nodes usually move well, but if the user cannot contact the nearest node, (s)he will not be able to get on the network. The issue is the "last mile" (or, conversely for the user, the "first mile").

39 C-DOT is working with NCMRWF on VSAT design and network development. The "METNET" will use INSAT, the C-Band, and the Chingleput earth station.

iii. **Service/Support.** This question is closely related to that of management (above). Who will provide training to new users and help to existing ones? Once again, if this function is contracted out, which organizations will be the main candidates?

7.1.5 INSDOC (NATIONAL SCIENTIFIC DOCUMENTATION CENTRE)

INSDOC is the organizer of the Scientific and Industrial Research Network (SIRNET). It is an ERNET subscriber, with about 60 members, most of which are CSIR labs. To get access, a user dials up one of the SIRNET nodes. Services available include email, file transfer, and access to INSDOC CAPS and on-line search facilities. Three issues have been important in the emerging ERNET–SIRNET relationship.

i. **Contractual Arrangements**. Most contracts have been for one year only and have had specified maximum traffic volumes. The latter condition may be acceptable to organizations primarily involved in R&D, but is less likely to be suitable for organizations like the ICAR that wish to use a network for management as well as scientific communication.
ii. **Financial Arrangements.** SIRNET is a paying subscriber to ERNET—but then resells ERNET services to its own constituent units for much less than they would pay as individual subscribers. ERNET is not happy at this practice, while SIRNET counters that its members cannot afford to pay regular ERNET rates.
iii. **Technical Arrangements.** When problems on ERNET have occurred, which SIRNET officials claim that they frequently do, there has been no fallback. SIRNET has attempted to deal with this issue by developing complementary relationships with NICNET and INET.[40]

7.2 Conclusion (Network Options)

Each of the organizations and networks described has strengths and weaknesses. None is perfect, though the ICAR must make a choice between them. That decision should be for ERNET.

The main reason(s) are set out in the table on pp.31-32. ICAR institutes and SAUs are primarily concerned with education and research, just as are most of the organizations involved in ERNET. These institutes and SAUs have a significant degree of autonomy which they value, and the same applies to most of the ERNET member organizations. Flexible email and file transfer capabilities are important, at high speeds, coupled with efficient international connectivity.

The main areas in which ERNET needs improvement are in its service and support polices, its training policies, and its costs. The ICAR will be in a position to strike good bargains in all three areas. A commitment to c.240[41] new sites will represent a 33%-50% increase in the size of ERNET, and the funds that the ICAR has available will enable a significant upgrade in ERNET capabilities to be put into effect.

A decision by the ICAR for ERNET does not mean that other potential national players should not or will not be involved.

i. NICNET offers access to a considerable number of national databases (e.g., on patents and medicine). It also manages a country-wide District

40 A network established and run by the Department of Telecommunications (DOT).

41 Approximately 80 ICAR institutes, 27 SAUs, 127 ZRSs, plus additional installations at ICAR headquarters.

Information System (DISNIC), in which district and sub-district socio-economic information is aggregated. The ARIS will want to include an efficient means of accessing such resources.

In addition, NIC itself may be a candidate for taking on one or more of the management contracts for IM at the "Demonstration Sites" (Section 11.2). And NIC is also likely to play a role in the proposed National Agricultural Technology Project (NATP). Its expertise in the management of district-level telecommunications will be important for strengthening the IM capabilities of farmers and extension services, as well as in the improvement of research/extension linkages.

ii. NCMRWF has signed a contract with C-DOT for the supply of 27 VSATs. The first ten will be installed at ten SAUs later this year and the remainder at 17 other SAUs in early 1995. The technical design team for the ARIS network will want to take these VSATs into account in its physical and management planning.[42] As noted above, NCMRWF has continually expressed interest in cooperating with the ICAR on network development.

iii. INSDOC is certain to play a major role in the implementation of the ARIS. In the list of "Required Actions in 1994-1996" (Section 13), there are several contracts to be awarded for which it would seem to be pre-eminently well qualified.

iv. The ICAR Computer Centre is the in-house operation at Krishi Bhawan. It can be expected to participate in whatever network development activities are finally implemented.[43]

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42 Different networks which use different types of (proprietary) VSATs may send different types of signals to a satellite. The satellite can usually receive them all. The problem, and potential cost, comes at the ground station, where the hubs of the different systems have to be linked. Any ICAR/SAU order for VSATs will therefore have to be made with a view to minimizing these compatibility issues.

43 The primary job of this unit is the maintenance of three databases: one on ICAR scientists, one on SAU budgets and manpower, and one on ICAR institute finances. *It has no experience in networks or telecommunications*, even though it is designing and implementing the third database in cooperation with NIC. The management of this database will be centralized. Institutes will use software that has been written by NIC and will enter data on, mostly, NIC-supplied PC's. These data will then be carried or sent to the site of the nearest NIC VSAT for forwarding to New Delhi. Analysis and reporting will all be done at the ICAR headquarters. There is no provision for institutes to be users of the data that they have supplied, and therefore perhaps no real incentive for them to cooperate fully.

8 TECHNOLOGY CHOICES

Technology for the ARIS network will balance the following considerations:

i. A track record, i.e., technology that has been proven to work.
ii. Growth potential, i.e., technology that will still be appropriate in at least the year 2010.
iii. Cost, i.e., technology that the ICAR can afford.
iv. Simplicity, i.e., technology that the ICAR and its collaborators can support, service, and maintain.

There are three broad technology categories for consideration: land lines (both leased and dial-up), satellites, and radio. The ARIS will almost certainly be based on a combination of the first two.

8.1 Land Lines

In terms of capacity and speed, there are strong arguments in favor of terrestrial lines. If all institutes, SAUs, and zonal research stations (ZRSs) could be connected with *reliable* land lines running through *reliable* telephone exchanges, the case for them would be very strong.

But these two conditions are not likely to be fully met in the near future. Even with the rapid growth of the Indian telephone network, the "last mile" issue is still a major one that the ICAR and the SAUs will have to address. Institute and SAU headquarters in urban areas will not usually be a problem, since a manager or scientist there can dial-up to the nearest ERNET node (via a trunk call if necessary). The problem comes for outlying stations and associated campuses. Many of these latter sub-units are in areas that are still not well connected by telephone. Also, even if the small town in which they are located has a new exchange, their offices are usually, at best, on the edge of town, and therefore a "last mile" problem. For most such units, there is no immediate relief in sight.

8.2 Satellites

India is recognized internationally as an emerging leader in satellite technology. It has several of its own satellites already in operation, and more are planned. The ICAR and the SAUs can choose to base an ARIS at least partially on satellites, but only if (at least) the following issues are satisfactorily dealt with.

8.2.1 COST

The major cost item in a satellite-based ARIS will be the VSATs. Most ICAR institutes, SAUs, and ZRSs will, initially, have to have one, and each outlying station and associated campus will, later, also need one. Several companies are now designing and making VSATs in India. The cost in 1993 was about 6 lakhs per unit, though this price can be expected to fall dramatically if there is a volume order. Besides the VSAT, the cost per installation at an ICAR institute or SAU is not significantly different whether a choice is made for land lines or satellite.

8.2.2 GUARANTEES OF TRANSPONDER SPACE

There is apparently no shortage of transponder space on the various INSATs. INSAT 1A and 2A are quite full, but INSAT 2B (1993) still has room in both the "C" and particularly the "Extended C" bands. INSAT 2C (1995) will have both "C" and "KU" band capabilities.

An ICAR and SAU choice for satellite technology will only be as part of a cooperative package with an existing network (e.g., ERNET). In the event of such a decision, the ICAR and the SAUs will have to make an arrangement that will guarantee the ARIS and its partner transponder space, reasonable pricing, and service for at least the medium-term.

8.3 Radio

India has not experimented much with digital communications by radio.[44] The reasons are not completely clear, though two may be hypothesized. First is that the major players in the national telecommunications market have been pushing other technologies: mainly VSATs (NIC) and telephones (Department of Telecommunications, DOT). And second is that there is a perceived problem with the allocation of frequencies by the GOI.

The primary advantage of radio is cost. A full installation at an ICAR institute or SAU would probably cost less than 1 lakh. A manager or scientist would use a radio to communicate with the nearest NICNET or ERNET node, just as (s)he would with a telephone. There would be no "last mile" problem. At the same time, however, there are four significant disadvantages to radio.

i. **Lack of Other Users.** At present, no major public organization or group in the country uses radio as its main telecommunications technology. The ICAR and the SAUs would therefore be largely on their own.
ii. **Range**. Most affordable radio technologies have a range of 40-80 kilometers. Such a range would put an institute or SAU in potential contact with a NICNET node, but not necessarily with an ERNET node.
iii. **Frequencies**. A radio network is completely dependent on frequencies being allocated by the government, and then not being changed too often.
iv. **Bandwidth**. Radio operates on a low bandwidth, which means that there are significant limitations on speed of transmission and size of messages.

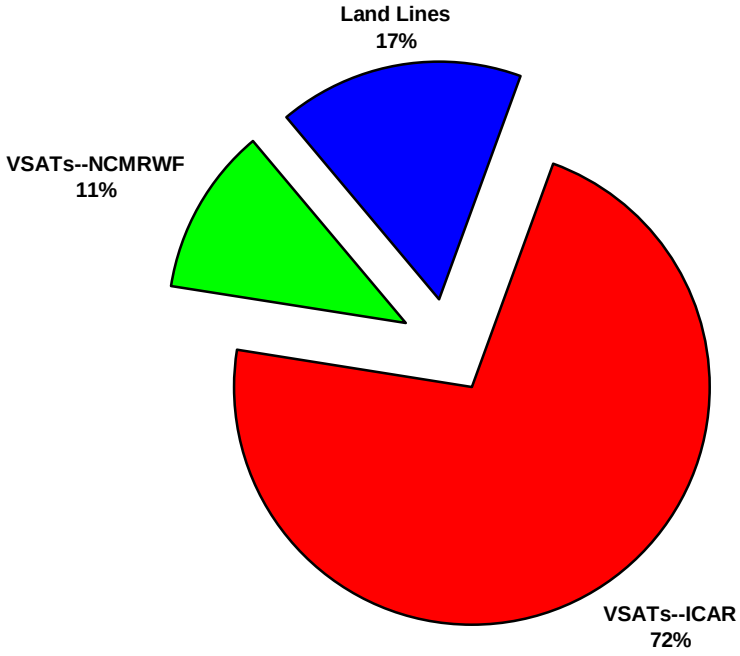
8.4 Conclusion (Technology Choices)

The ARIS network will be based on a combination of land line and satellite technologies. As VSAT prices fall and satellite transponder space increases, the ICAR can realistically consider a mixed system.

The basic approach will be to use land lines whenever possible. As noted above, institute headquarters in urban areas will usually be able to dial up to the nearest ERNET node. If telephone connections are a practical alternative for these sites, they will be preferred—and such institutes will be provided with high-speed modems.

At the same time, the remaining institutes, all SAUs, and most ZRSs will get VSATs. The SAUs will be getting them anyway through the NCMRWF program. Of the

44 A major trial of radio technology is planned for Haryana, where the objective is to put a radio communications capability in each "tehsil" in the state. At IISc in Bangalore, scientists have developed ASTRA (Application of Science and Technology to Rural Areas), a radio-based field network that links IISc field programs. And C-DOT has developed a single-channel VHF radio, that costs only about Rs. 20,000 but which has not yet been field-tested.



c.240 sites to be linked by the end of 1996, the estimate at present is that c.40 will be able to use land lines (dial-up and leased) and 27 will be provided for under the NCMRWF program. About 175 will therefore require new VSATs.

9 SOFTWARE AND HARDWARE

In 1991, when the ICAR first began to discuss the ARIS, the assumption was that most software would be DOS-based. There were two reasons for this preference. First, the majority of software in use both inside and outside India at that time was for DOS. "Windows"[45] and other Graphical User Interfaces were still in their early development stages. Second, at that time, most PCs in India were XTs[46] or ATs,[47] which were not suitable for running GUIs anyway.

However, there have been significant changes in both the software and hardware markets in the past three years. "Windows"-based software is now the standard in both North America and Western Europe. Several major software developers have stopped work on their DOS-based products altogether. Within 1-2 years, DOS itself will no longer be widely sold as a separate product, but will instead be a specialist item produced only for a niche market.

The ARIS will require that each institute, SAU, and ZRS use a small set of standard software (Section *4.1.1.1.*). The objective of such standard-setting is "integration", which has two definitions here.

i. Between organizations. Institutes, SAUs, and ZRSs will only be able to share data if they are using at least some of the same software.
ii. On a single PC. At least some individual users will want to be able to share data between spreadsheets, databases, and/or word processors.

The ICAR will have three choices in deciding which software should be used.

i. Separate programs. One spreadsheet, one database, and one word processor. The most widely-used Windows-based spreadsheet is EXCEL (from Microsoft). The preferred database options are ACCESS (from Microsoft) and PARADOX (from Borland). And the emerging word processing standard is WORD FOR WINDOWS (also from Microsoft).
ii. One "suite" of programs from the same manufacturer (including a spreadsheet, database, and word processor). The advantage of a "suite" is that all components ideally have the same "look-and-feel". These components are designed to work together (i.e., to allow the transfer of data from one to another). And, perhaps most important for the ICAR, it is easier to learn three similar components than three very different ones. The "suite" with the biggest market share is MICROSOFT OFFICE PROFESSIONAL.[48]
iii. One "integrated" program (including spreadsheet, database, and word processing modules). This option is the simplest one. Instead of 3-4 programs, there is only one—and the modules are even more tightly integrated with each other than are the components of a "suite". For most institutes, SAUs, and particularly ZRSs, this choice will be the most logical one. The preferred choice is MICROSOFT WORKS FOR WINDOWS.

In addition, each set of standard software will include a data compression program (to allow more economical transmission of data over the network). The worldwide standard is PKZIP (from PKWare).

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45 From Microsoft.

46 With 8086 processors.

47 With 286 processors.

48 Including EXCEL, WORD FOR WINDOWS, ACCESS, and POWERPOINT (a graphics program).

Rapid developments in software have necessitated complementary changes in hardware. "Windows" will not run on an XT and only with great difficulty on an AT. Both such types of PC—which were the standards in India throughout the 1980s and into the early 1990s—are now basically out of production. Even 386s are now considered marginal entry-level machines. All new machines purchased for the ARIS will therefore have to be 486s or Pentiums, configured with at least 4MB of RAM,[49] a 200MB hard disk, and VGA.

In addition, each PC that is to be used as a network access point must be connected to a modem. The emphasis in all modem purchases will be on quality, i.e., the ability to handle different and often difficult phone line conditions. Speed will be a secondary consideration. Slower modem speeds may sometimes be more reliable, even though there is an obvious trade-off with higher telephone charges.

49 Upgradeable to 8MB or 16MB without replacement.

10 ORGANIZATION AND MANAGEMENT

Overall policy and management for the ARIS will be coordinated by the ICAR headquarters. A new IM unit in Krishi Bhawan will have the following three characteristics.

i. A mandate for information that runs well beyond computers.
ii. Staff with experience in research, IM, and project management.
iii. Direct access to the Director General.

10.1 Structure

The project management structure for the ARIS will have three parts.

i. The IM Unit. This Unit will be part of the office of the Director General in Krishi Bhawan. It will be small, probably no more than 3-4 full-time professionals initially. The head will most likely be a senior ICAR official with demonstrated interest in and commitment to IM issues. Appointment of this latter individual may be at the DDG level.

   The IM Unit will have a substantial budget that will enable it to hire consultants as required. These consultants will be involved in the performance of at least the two following functions:

   a. Preparation of Terms of Reference for Contractors
   b. Monitoring of Contractor Performance

ii. Two-four non-ICAR agencies contracted specifically for ARIS project management. These agencies will be given mandates for network design, hardware procurement, installation, and commissioning in specific geographic regions.

   The award of these contracts will be critical to the success of the entire ARIS endeavor. The ICAR does not now have the IM expertise in-house to get such a large project started.

   The ICAR is not alone on this issue. The computer and telecommunications field is changing so rapidly that it is often impossible for organizations to develop and maintain sufficient IM expertise in-house. Many of these organisations, both in India and abroad, routinely turn to specialized outsiders for management of their information operations. In India, there are several organizations that are getting into this "outsourcing" business, which would be possible collaborators for the ICAR.[50]

iii. In addition to the IM unit, there will also be an "ARIS Steering Committee". This committee will have two primary functions.

   a. To advise the ICAR Director General on matters of ARIS policy and management.
   b. To organize frequent reviews of progress on the project (e.g., quarterly, or at least semi-annually). These review teams may have both national and international members.

50 A preliminary list would probably include CMC, ISRO (The Indian Space Research Organization), TCIL (Telecommunications Consultants India Limited), TCS (Tata Consultancy Services), Wipro Infotech, and NCST (The National Center for Software Technology).

The Steering Committee will consist of representatives from the public and private sectors, and from the agricultural and information sectors. The two-four agencies contracted for project management (see "ii" immediately above) will participate.

10.2 Functions of the IM Unit

The Unit will have two main responsibilities: overall project management and public relations.

i. **Project Management.** This responsibility will be the first and most important one. The precise tasks that fall under this heading will be defined by the Director General, the Steering Committee, and the IM Unit itself. Over the remaining 12-24 months of the NARP, they will include at least the following activities:

   a. Design of the ARIS Network. Technical specifications for land line and VSAT installations, modems, PCs, telecommunications software, etc.
   b. Procurement of required hardware and software.
   c. Installation of this hardware and software at institutes, SAUs, and ZRSs.
   d. Basic training for staff at these institutes, SAUs, and ZRSs.
   e. Organization of support and maintenance services.
   f. Supervision of the "Demonstration Sites" program (Section 11).

   For each of these activities, the IM Unit—assisted by consultants as required—will draw up precise terms of reference, supervise the awarding of contracts, and monitor progress.

ii. **Public Relations.** A second major task for the IM unit will be the building of support for the ARIS. Most managers and scientists at institutes, SAUs, and ZRSs do not currently know much about the potential of an electronic network. They can be expected to have many questions. One preliminary way to answer such questions, and to develop consensus about the ARIS, is for the IM Unit to organize a series of seminars and workshops. These events can be held both in New Delhi and in the states, and will probably deal with at least the following issues:

   a. What will I be able to use the ARIS for? Both at the beginning and later on?
   b. How much will the ARIS cost my institute, SAU, or ZRS?
   c. What will be my obligations in accepting an ARIS installation?
   d. What support can I expect from the IM Unit at the ICAR HQ?

   In addition to such seminars and workshops for participants in the ARIS, the IM Unit will also need to provide continuing information about the network to audiences outside the NARS. The ARIS will be only a small part of an emerging Indian Internet-connected community.

11 DEMONSTRATION SITES

An important feature of the early days of the ARIS will be intensive work at a small number of demonstration sites. There will probably be 4-6 such locations: 2-3 ICAR institutes and 2-3 SAUs (including their associated ZRSs). This DS programme will have two objectives.

i. Research and Development (R&D). The first objective of work at the DSs will be to find out what works with the ARIS and what does not. Each of the DSs will receive a heavy dose of technology. Probable activities at each DS will include the following:

   a. Development of LAN capabilities within the campus, through which all scientists and managers will be able to access the national network.
   b. Development of "wide area network" (WAN) capabilities between the campus and constituent stations and/or colleges, thereby allowing almost immediate communication on both management and scientific matters.
   c. Library automation.
   d. Computerization of selected experimental records.
   e. Computerization of accounts.
   f. Development of other management databases (e.g., for personnel and physical facilities).

ii. Education and Training (E&T). A second objective of the DS program will be to create staff development hubs within the ARIS network. Each DS will be expected to become a focal point for the training of managers and scientists from other institutes, SAUs, and ZRS.

11.1 Benefits & Responsibilities

Each institute and SAU that participates in the DS programme will receive at least the following benefits:

i. Provision of hardware and software, paid for by the ARIS.
ii. Posting of technical support personnel at the institute/SAU, paid for by the ARIS.
iii. Intensive training of institute/SAU personnel in the use of ARIS-supplied technology.
iv. Development of a position both within the NARS and outside as a leader in IM.

At the same time, each such institute/SAU will be asked to make the following commitments.

i. To make the management changes necessary to get the ARIS going.
ii. To inject financial resources to supplement funds from the ARIS project budget (if necessary).
iii. To undertake a systematic program of internal staff training in IM.
iv. To agree to become a hub for training and support to other institutes and SAUs in the ARIS network.

11.2 Management of the DS Program

The ICAR will award responsibility for management of the DS program to organizations with proven experience in IM. Since one of the objectives of the program is R&D, there is not likely to be a single "correct" approach. There will therefore probably be several sub-contractors.[51] The IM Unit in ICAR HQ will organize periodic evaluations of experience at the DSs, with a view to developing principles and guidelines that can be used at other institutes and SAUs.

11.3 Possible Locations for the DS Program

The following four considerations will be taken into account in identifying institutes and SAUs that will be invited to become DSs:

i. A high level of current awareness about the importance of IM, among both managers and scientists.
ii. A significant amount of IT already in place (e.g., PCs).
iii. A size that will make the introduction of the ARIS manageable.
iv. Representation of the four states that will be included in the National Agricultural Technology Project (NATP).[52]

The following institutes and SAUs would seem to meet some or all of the above criteria, and might therefore be *possible* DSs.

i. The Central Institute of Fisheries Education (CIFE, Bombay)
ii. The Indian Institute of Horticulture Research (IIHR, Bangalore)
iii. The Central Soil Salinity Research Institute (CSSRI, Karnal)
iv. The Central Institute of Freshwater Aquaculture (CIFA, Bubaneshwar)
v. Gujerat Agricultural University (GAU)
vi. Kerala Agricultural University (KAU)
vii. Dr. Yashwant Singh Parmar University of Horticulture & Forestry (YSPUHF)
viii. Punjab Agricultural University (PAU)

51 Possible candidates include NIC, INSDOC, and NAARM. International organizations with experience in information management might also be possibilities.

52 Maharashtra, Gujerat, Orissa, and Punjab. As noted above, the NARP is projected to end in June 1995. It will be followed by the NATP, which will provide funds for the continuation of ARIS.

12 MAJOR ELEMENTS OF THE STRATEGY

i. Establishment of a national telecommunications network for agricultural research, comprising approximately 240 sites by the end of 1996, based on a mixture of land line and satellite technologies.
- Section 7.2

ii. Commitment to standard Internet (ERNET) technology for this network.
- Section 7.1.2, Section 7.1.3

iii. Establishment of an Information Management Unit in the office of the ICAR Director General in Krishi Bhawan.
- Section 10

iv. ICAR commitment to contract out most elements of project management and implementation.
- Section 10.1

v. Adoption of a minimum set of standard PC-based software.
- Section 4.1.1.1, Section 4.1.1.2
- Section 4.2.2.1
- Section 9

vi. Intensive information development at selected ICAR institutes and SAUs.
- Section 11

vii. Development of a prototype “Management Information System”.
- Section 4.1

viii. Strengthening of four “National Agricultural Information Centres”.
- Section 4.2.2

ix. Development of new procedures for document identification and access.
- Section 4.2.2.2
- Section 4.2.2.3
- Section 4.3.1.4
- Section 6.2

x. Training of managers, scientists, and information professionals.
- Section 4.1.1.4
- Section 4.2.2.5
- Section 4.3.1.1

13 REQUIRED ACTIONS IN 1994-1996

Establishment of an IM Unit in ICAR. This Unit will be located in Krishi Bhawan, in the office of the ICAR Director General.

Appointment of a senior agricultural research manager to head this Unit.

Identification of 2-3 ICAR institutes and 2-3 SAUs for intensive information development ("Demonstration Sites").

Contracts To Be Awarded

Consultant Contracts

For assistance to the IM Unit. To advise on Terms of Reference for the management contracts noted below, as well as to advise on performance monitoring under those contracts.

Management Contracts

- For design of the ARIS network, including the development of detailed technical specifications.
- For procurement of network hardware, installation, and commissioning. Several separate contracts.
- For network service, support, and maintenance.
- For supply of PCs to ICAR institutes and SAUs.
- For supply of approximately 500 sets of standard PC-based software, to be distributed to the c.240 sites on the network.
- For management of an intensive information development program at 2-3 ICAR institutes and 2-3 SAUs ("Demonstration Sites"). 4-6 separate contracts.
- For development of a prototype "management information system", including introduction and testing of this MIS at the DSs.
- For an evaluation of library automation and computerization systems, including recommendations on a standard package (or packages) for ICAR institutes and SAUs.
- For supply of a limited number of these library package(s)—including installation, training, and on-site support for at least 2-3 years.
- For a study of options regarding AGRIS input.
- For a program to make existing "current awareness" and "bibliographic search" facilities more available to agricultural scientists.
- For training managers, scientists, and information professionals from the c.240 network sites. Subjects to include the use of network hardware (e.g., email), the use of standard software, management information systems, and library management using new technologies (e.g., computerized catalogs, on-line searches, CD-ROMs). Several contracts.

14 SCHEDULE (THROUGH 1996)

A preliminary schedule for the next three years will look roughly as follows:

Before December 31, 1994	• Establishment of the IM Unit • Design: Development of technical specifications for the network • Design: Development of technical packages for each site
Before June 30, 1995	• Procurement: Basic hardware/software • PR: Organization of seminars for managers and scientists • Preparation for installation
Before December 31, 1995	• Installation: At least 50 sites • Organization of maintenance and support services
Before June 30, 1996	• Installation: At least 50 more sites
Before December 31, 1996	• Installation: Remaining c.140 sites

15 TERMS OF REFERENCE FOR DESIGN AND IMPLEMENTATION

Sections 10 and 13 above.

16 BUDGET

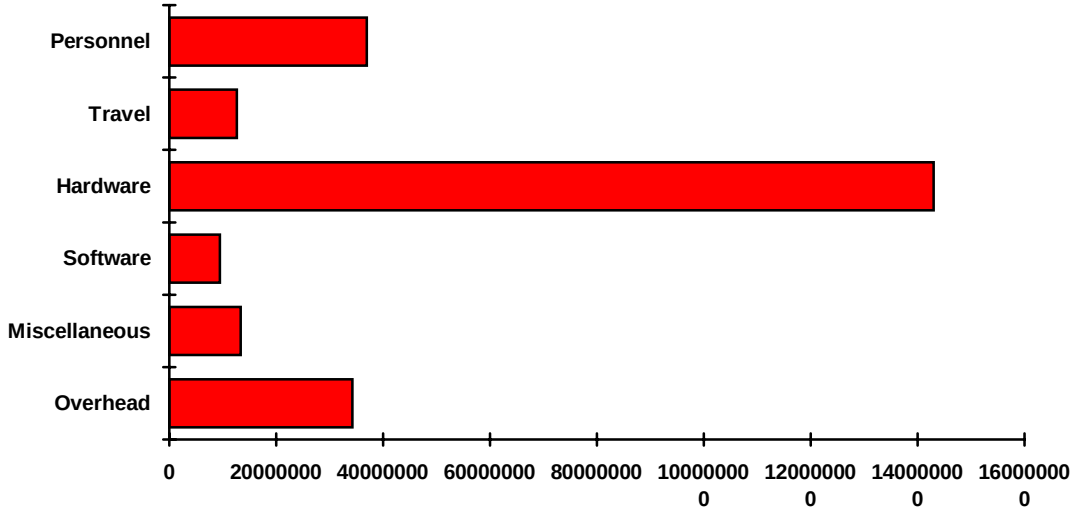
ARIS activities in the period 1994-1996 will be divided into 4 main projects, which in turn will be divided into 12 sub-projects.

i. Operations of the IM Unit
ii. Project Management, Network Design, and Implementation
- Initial Technical Design of the ARIS Network
- Procurement and Installation of Network Hardware
- Supply of PCs to ICAR Institutes and SAUs
- Supply of 500 Sets of Standard PC Software
- Supply of 30 Sets of Library Automation Software, Including Support
- Ongoing Network Design, Service, Support, & Maintenance

iii. Initial Network Use
- ERNET Subscriptions
- Information Management at 4-6 Demonstration Sites
- Improved Use of Existing "Current Awareness" Facilities

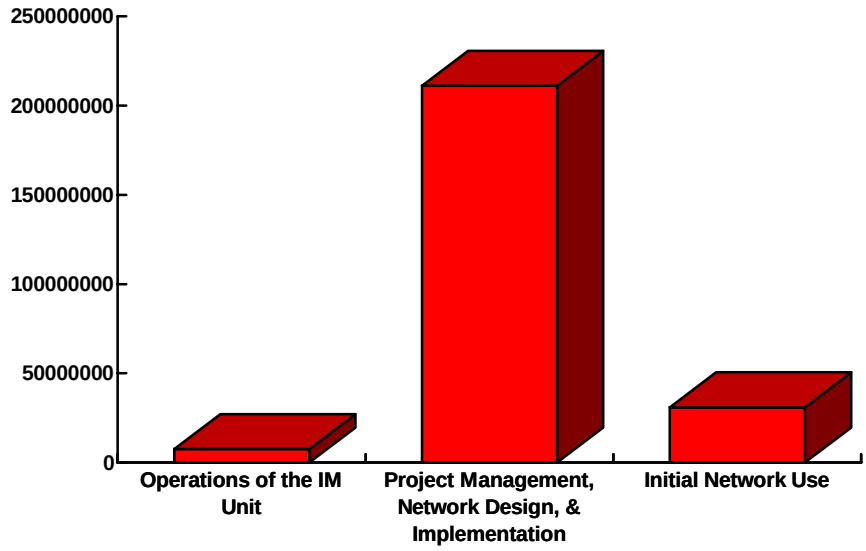
iv. Selected Aspects of Information R&D (Funds from ICAR/SAUs)
- Development of a Prototype "Management Information System"
- Evaluation of Library Automation Systems
- Study of Options Regarding AGRIS Input
- Development of a Training Master Plan

About 25 crores[53] will be needed to get the network started. Projected expenditure in the period to December 1996 will be divided as follows:



[53] One crore equals ten million rupees.

Between the first three main projects noted on the previous page, by far the largest share will go to the second.



17 ACRONYMS

AICRP	All-India Coordinated Research Project
ARIC	Agricultural Research Information Centre, New Delhi
ASTRA	Application of Science and Technology to Rural Areas
C-DOT	Centre for Development of Telematics
CIFE	Central Institute of Fisheries Education, Bombay
CMC	(formerly) Computer Maintenance Corporation
CSIR	Council for Scientific and Industrial Research
DELNET	Delhi Library Network
DOE	Department of Electronics
DOT	Department of Telecommunications
DST	Department of Science and Technology
ERNET	Education and Research Network
IARI	Indian Agricultural Research Institute, New Delhi
IDRC	International Development Research Centre
IIM	Indian Institute of Management, Ahmedabad
IISc	Indian Institute of Science, Bangalore
IITs	Indian Institutes of Technology
INSDOC	Indian National Scientific Documentation Centre, New Delhi
ISNAR	International Service for National Agricultural Research, The Hague
ISRO	Indian Space Research Organization, Bangalore
IVRI	Indian Veterinary Research Institute, Izatnagar
KAU	Kerala Agricultural University, Thrissur
NAARM	National Academy of Agricultural Research Management, Hyderabad
NARP	National Agriculture Research Project
NATP	National Agricultural Technology Project
NCMRWF	National Centre for Medium Range Weather Forecasting
NCSI	National Centre for Science Information, Bangalore
NCST	National Centre for Software Technology, Bombay
NDRI	National Dairy Research Institute, Karnal
NIC	National Informatics Centre, New Delhi
NICNET	National Informatics Centre Network
NISSAT	National Information System for Science and Technology
SIRNET	Science and Industrial Research Network
STP	Software Technology Park, Bangalore
TCIL	Telecommunications Consultants India Limited, New Delhi
TCS	Tata Consultancy Services

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